MCP1643 RGB LED Driver Demonstration Board User's Guide

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QUALITY MANAGEMENT SYSTEM
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Object of Declaration: MCP1643 RGB LED Driver Demonstration Board

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Manufacturer: Microchip Technology Inc.
                     2355 W. Chandler Blvd.
                     Chandler, Arizona, 85224-6199
                     USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson
VP Development Tools

12-Sep-14
Date

NOTES:

MCP1643 RGB LED DRIVER DEMONSTRATION BOARD USER'S GUIDE

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MCP1643 RGB LED DRIVER DEMONSTRATION BOARD USER'S GUIDE

Preface

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP1643 RGB LED Driver Demonstration Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in This Guide
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP1643 RGB LED Driver Demonstration Board. The document is organized as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1643 RGB LED Driver Demonstration Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and getting started with the MCP1643 RGB LED Driver Demonstration Board.
- **Chapter 3. "Flow Charts"** - Contains flow charts for the MCP1643 RGB LED Driver Demonstration Board.
- **Appendix A. "Schematics ad Layouts"** – Shows the schematic and layout diagrams for the MCP1643 RGB LED Driver Demonstration Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP1643 RGB LED Driver Demonstration Board board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, Italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	`file`.o, where `file` can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options] file [options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void)` `{ ...` `}`

RECOMMENDED READING

This user's guide describes how to use the MCP1643 RGB LED Driver Demonstration Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **MCP1643 Data Sheet – "***1 MHz Low Start-up Voltage Synchronous Boost LED Constant Current Regulator***" (DS20005208)**
- **PIC16F1455 Data Sheet –** *"USB Port Power Controller with Charger Emulation"* **(DS200005346)**

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- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives.

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- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE™ and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debuggers. This includes MPLAB ICD 3 in-circuit debuggers and PICkit™ 3 debug express.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include production programmers such as MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger and MPLAB PM3 device programmers. Also included are nonproduction development programmers such as PICSTART® Plus and PICkit 2 and 3.

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at:
http://www.microchip.com/support.

REVISION HISTORY

Revision A (January 2016)

- Original release of this document.

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP1643 is a compact, high-efficiency, fixed frequency, step-up DC-DC converter optimized as an LED constant current generator. The device provides an easy-to-use power supply solution, with a minimum number of external components for applications powered by one-cell, two-cell Alkaline, NiCd or NiMH batteries.

This chapter provides an overview of the MCP1643 RGB LED Driver Demonstration Board and covers the following topics:

• MCP1643 Device Overview
• MCP1643 Device Key Features
• MCP1643 RGB LED Driver Demonstration Board Overview
• MCP1643 RGB LED Driver Demonstration Board Features
• What the MCP1643 RGB LED Driver Demonstration Board Kit Includes

1.2 MCP1643 DEVICE OVERVIEW

The MCP1643 is a PWM-only device that operates at a fixed 1 MHz switching frequency. The device has an operating input voltage range from 0.5V to 5V ($V_{IN} < V_{LED}$), with a 0.65V start-up voltage.

For applications that require dimming, the LED can be turned on and off with a variable duty cycle applied to the EN pin. The maximum dimming frequency is only limited by the internal soft-start of 240 μs. The device is available in 8-lead MSOP and 8-lead 2x3 mm DFN packages.

1.3 MCP1643 DEVICE KEY FEATURES

• 1.8A typical peak input current limit
• Up to 550 mA LED load current
• Low start-up voltage: 0.65V (typical, 25 mA LED current, for V_{IN} > 2.2V)
• Low operating input voltage: down to 0.5V
• Maximum input voltage <V_{LED}<5.0V
• Maximum output voltage: 5V
• Overvoltage protection (5V)
• Low reference voltage:
  - V_{FB} = 120 mV
  - Minimal power loss on sense resistor
• Pulse-Width Modulation mode operation (1 MHz)
• Internal synchronous rectifier
• Internal compensation
• Inrush current limiting
• Internal soft start (240 μs typical)
• Shutdown (EN=GND):
  - True load disconnect
  - Dimming control by variable duty cycle

- Shutdown current: 1.2 µA (typical)
- Overtemperature protection (+150°C, with +25°C hysteresis)
- Packages: 8-lead MSOP and 8-lead 2x3 mm DFN

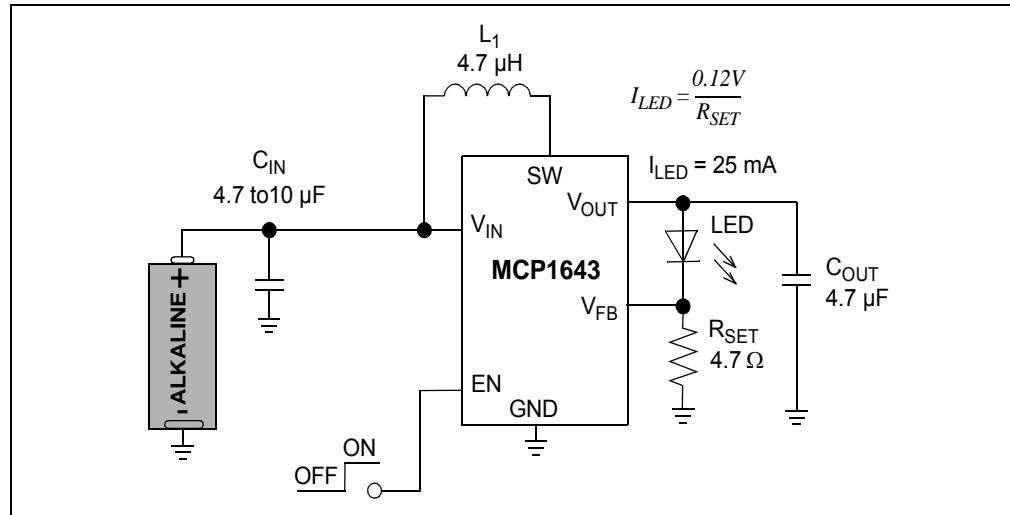Figure 1-1 illustrates the typical application with one battery.

$$I_{LED} = \frac{0.12V}{R_{SET}}$$

FIGURE 1-1: *Typical MCP1643 Boost Converter Single Cell Battery Input.*

1.4 MCP1643 RGB LED DRIVER DEMONSTRATION BOARD OVERVIEW

The MCP1643 RGB LED Driver Demonstration Board is used to demonstrate Microchip Technology's MCP1643 device in a boost converter application supplied by one AA battery, or from an external voltage source, which drives each color of the RGB LED separately at a constant current of 350 mA. A PIC® microcontroller drives each color of the RGB LED at a frequency of 70 Hz. The MCP1643 RGB LED Driver Demonstration Board was developed to help engineers reduce product design cycle time.

The intensity of each color of the LED can be adjusted using individual potentiometers for each color. The RGB LED is driven by a microcontroller with 3 PWM signals, and by modifying the duty cycle of each signal, the brightness of each color can be altered.

The MCP1643 RGB LED Driver Demonstration Board is controlled using two buttons:

- **Start**: to enable the MCP1643 and start the microcontroller
- **Stop/Demo**: to stop or run a demonstration program

When disabled, the MCP1643 disconnects the path from input to output for true-disconnect. In this state, the current consumed from the battery is typical 1.2 µA.
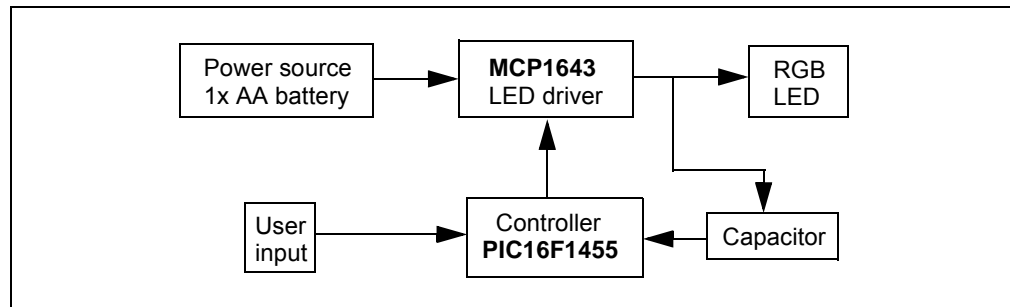
FIGURE 1-2: *MCP1643 RGB LED Driver Demonstration Board Block Diagram.*

1.5 MCP1643 RGB LED DRIVER DEMONSTRATION BOARD FEATURES

- Powered by one-cell Alkaline, NiCD, or NiMH battery or by external power supply
- Input voltage range (V_{IN}): 0.65V to 2V, with $V_{IN} < V_{OUT}$, after start-up
- Start-up voltage: 0.8V at full load
- MCP1643 PWM switching frequency: 1 MHz
- RGB multiplexing frequency: 70 Hz
- Fixed output current for all colors: 350 mA
- **Start/Stop** functions with push buttons
- Demonstration program

1.6 WHAT THE MCP1643 RGB LED DRIVER DEMONSTRATION BOARD KIT INCLUDES

The MCP1643 RGB LED Driver Demonstration Board Kit includes the following items:

- MCP1643 RGB LED Driver Demonstration Board (ADM00612)
- Important Information Sheet

NOTES:

Chapter 2. Installation and Operation

2.1   INTRODUCTION

The MCP1643 RGB LED Driver Demonstration Board has been developed for applications that require driving an LED from a low-voltage source. The low-voltage technology developed by Microchip Technology allows the device to start up from a low 0.65V input voltage without output overshoot. Also, the device is capable of achieving high efficiency by integrating the low resistance N-Channel boost switch and the synchronous P-Channel switch, and by using a low-voltage reference of 0.120V.

Figure 2-1 illustrates the components from the front view.
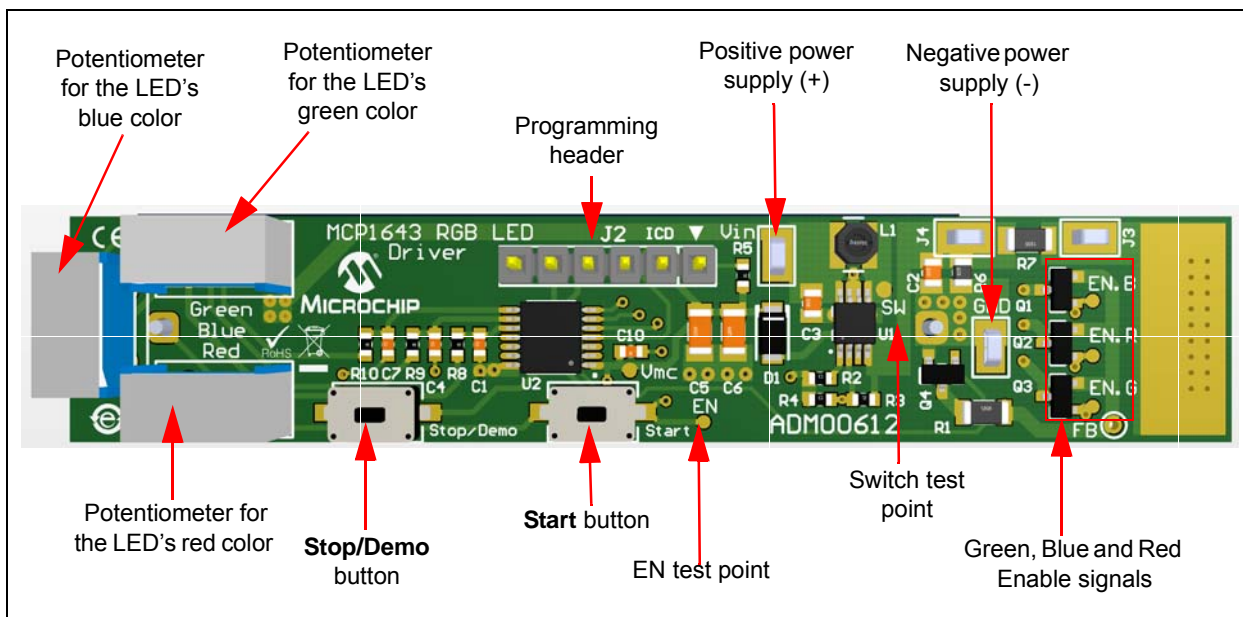
FIGURE 2-1:   *MCP1643 RGB LED Driver Demonstration Board - Front View.*

Figure 2-2 illustrates the components from the back view.
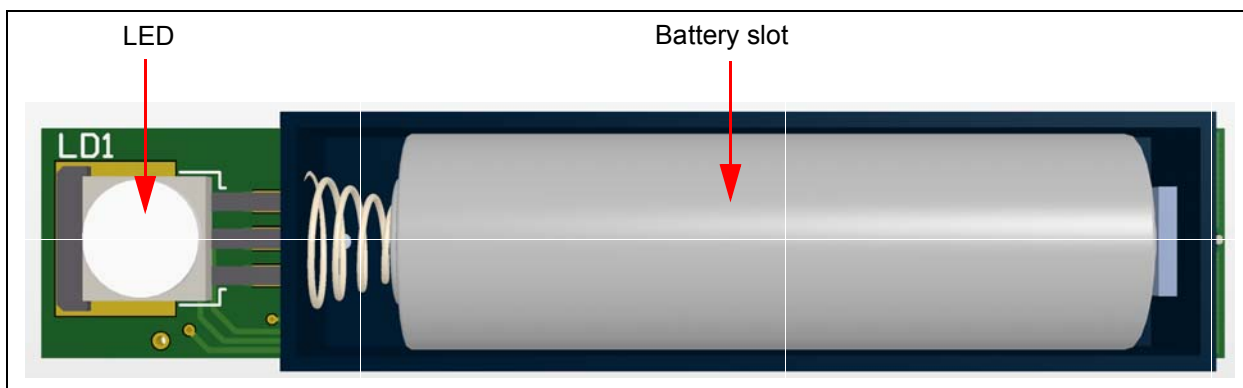
FIGURE 2-2:   *MCP1643 RGB LED Driver Demonstration Board - Back View.*

2.2   GETTING STARTED

The MCP1643 RGB LED Driver Demonstration Board is fully assembled and tested to evaluate and demonstrate the MCP1643 product operating with an external PWM signal. This board requires the use of an external power supply or a AA battery.

The package selected for the MCP1643 is the MSOP-8.

2.2.1   Powering the MCP1643 RGB LED Driver Demonstration Board

Soldered test points are available for input voltage connections. The maximum input voltage should not exceed 2V due to the forward voltage of the LED's red color of 2.1V. The forward voltage for the blue and green colors is 3.5V.

After connecting an external power supply or an AA battery, the board enters the Shutdown mode and only consumes 1.2 µA of current. To start the board, press the **Start** push-button. The second push-button has two functions: a short press shuts down the board, while a long press of more then 0.5 sec puts the board in a temporal demonstration state.

2.3   BOARD TESTING

Follow these steps to test the board functionalities:

1. Connect the input supply as shown in Figure 2-3,or connect a AA battery in the battery slot on the back of the board. Please observe the polarity to avoid board damage.
2. Press the **Start** push-button to enable the converter. The board will run a start-up demonstration program with all colors at low brightness, after which the user will be able to control the brightness. It is recommended to avoid looking directly into the LED, to prevent eye damage.
3. Change each color brightness by using the three potentiometers marked Red, Green and Blue, corresponding to each color of the RGB LED.
4. To run the demonstration program, press the **Stop/Demo** push-button for 0.5s.
5. To stop the MCP1643 RGB LED Driver Demonstration Board, short-press the **Stop/Demo** button.
6. Additional test points are available to visualize different signals (FB, output current, EN, SW).
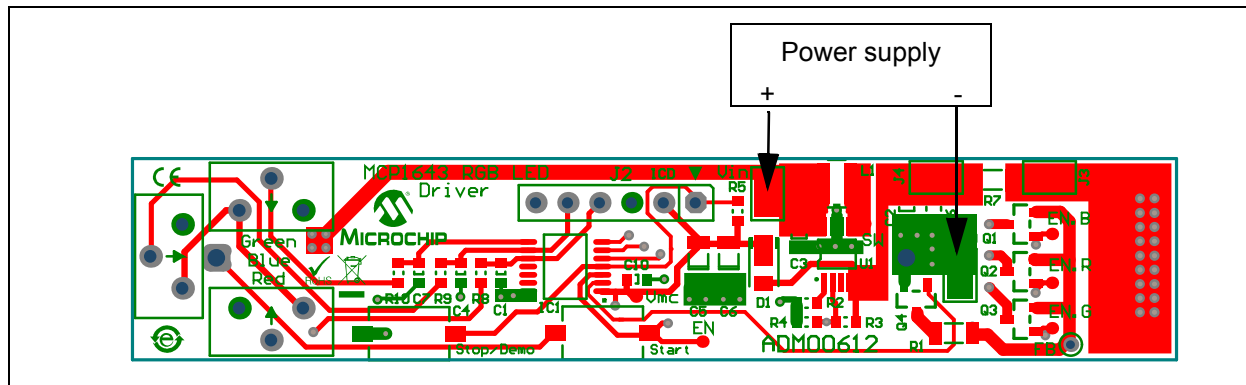

FIGURE 2-3:   *MCP1643 RGB LED Driver Demonstration Board Power Supplies.*

A 0Ω (R7) resistor is used for bench testing. By removing R7, the soldered test points can be used to create a wire loop and visualize the current through the LED by using an oscilloscope current probe.

2.3.1 How does the MCP1643 RGB LED Driver Demonstration Board Work?

When the **Start** button is pressed, the MCP1643 RGB LED Driver Demonstration Board receives an EN pulse and the device starts switching. When the output voltage rises above 2.3V, the microcontroller starts, enables the MCP1643 and controls the RGB LED in order to power each color independently (see Figure 2-4). The amount of time each LED is ON is set by the user through the three potentiometers.
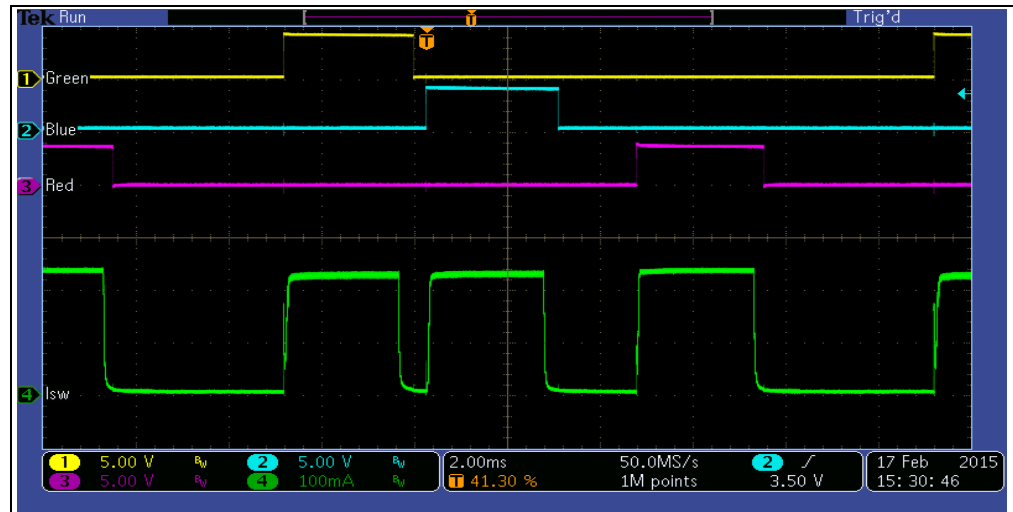

FIGURE 2-4:   *RGB LED Enable Signals and LED Current.*

An idle time is necessary between each color to ensure that the output voltage of the MCP1643 is below the LED voltage, otherwise the LED can be damaged by a current spike caused by the output capacitor discharge. The idle time can be optimized for different LED voltage differences to increase performance.

2.3.2 MCP1643 as a Voltage Source

In order for the MCP1643 RGB LED Driver Demonstration Board to be a single-switcher design, the MCP1643 is also used as a voltage source for the control system; the PIC16F1455 turns on the MCP1643 for a brief period without any LED connected, but with a resistor divider on V_{OUT} and Feedback. This forces the MCP1643 to increase the output voltage to 4V. This voltage is stored (through a diode) in a capacitor in order to power the control system while the MCP1643 is driving the LEDs. The diode is necessary because the energy stored in the capacitors would otherwise uncontrollably discharge into the LED.
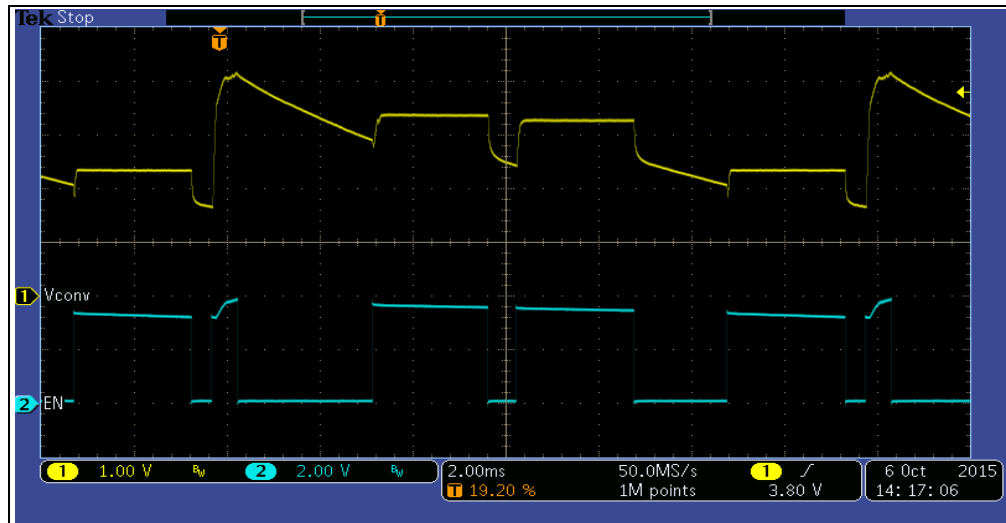
FIGURE 2-5:   PIC16F1455 Output Voltage and Enable Signal

2.3.3 Programming the PIC16F1455 Microcontroller

The board comes factory-programmed with the demonstration program, and features a 6-pin 2.54 mm header for future programming. A PICkit™ 3 In-Circuit Debugger may be connected to J3 to program the MCP1643 RGB LED Driver Demonstration Board.

The MPLAB® XC8 C Compiler is used to compile the source code and create the hex file to be used with the reference board. The XC8 compiler is available for download on the Microchip web site. The source code is rich in comments and helps the user understand the functionality.

> **Note:**   In order to program the MCP1643 RGB LED Driver Demonstration Board, all potentiometers must be set to the middle position. This is necessary because the potentiometers use the same data lines as the PICkit 3.

Chapter 3. Flow Charts

This chapter shows the flow charts for the MCP1643 RGB LED Driver Demonstration Board.

Figure 3-1 depicts the Main routine flow chart.
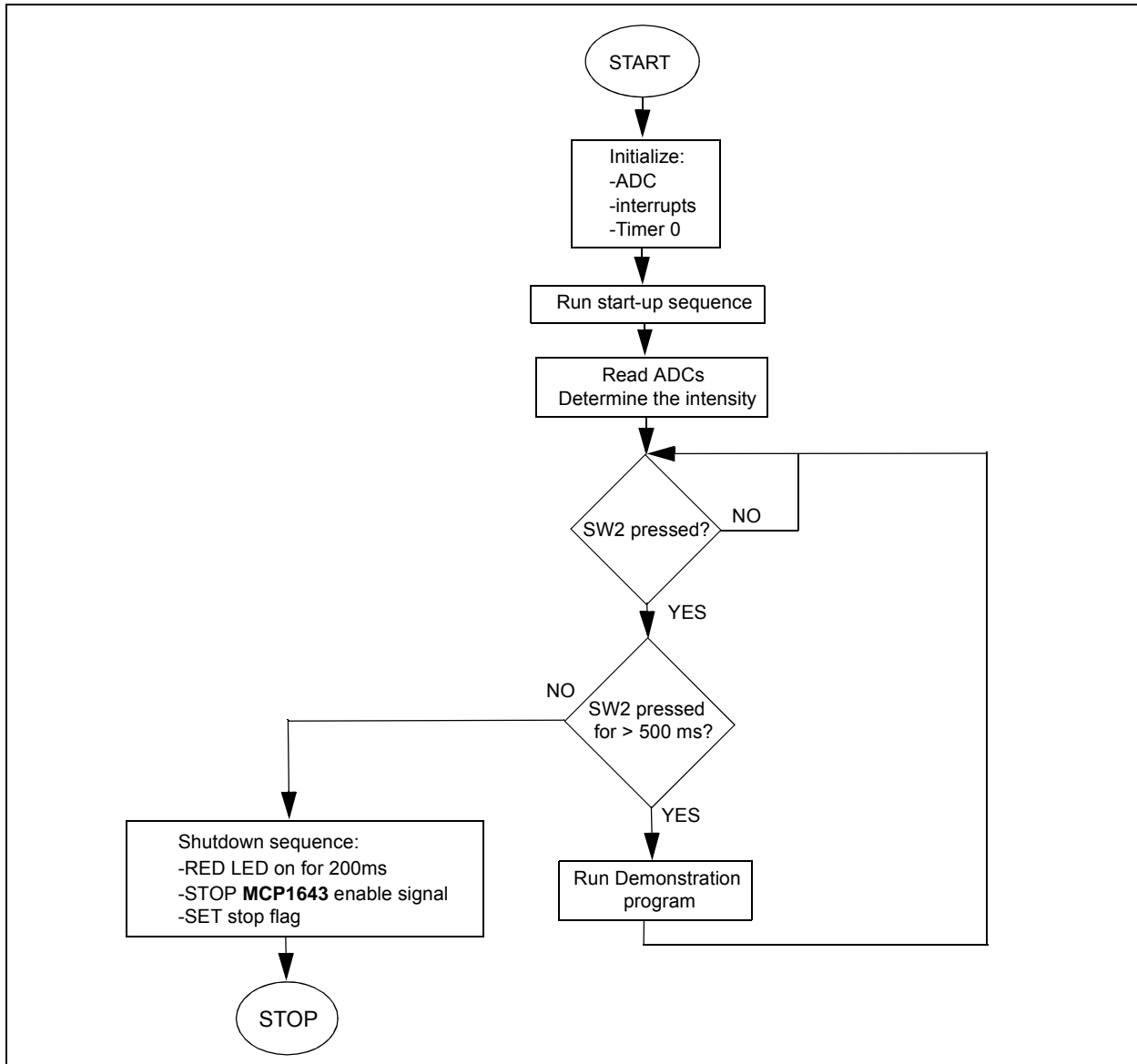
FIGURE 3-1:   *Main Code Sequence.*

Figure 3-2 depicts the Interrupt routine flow chart.
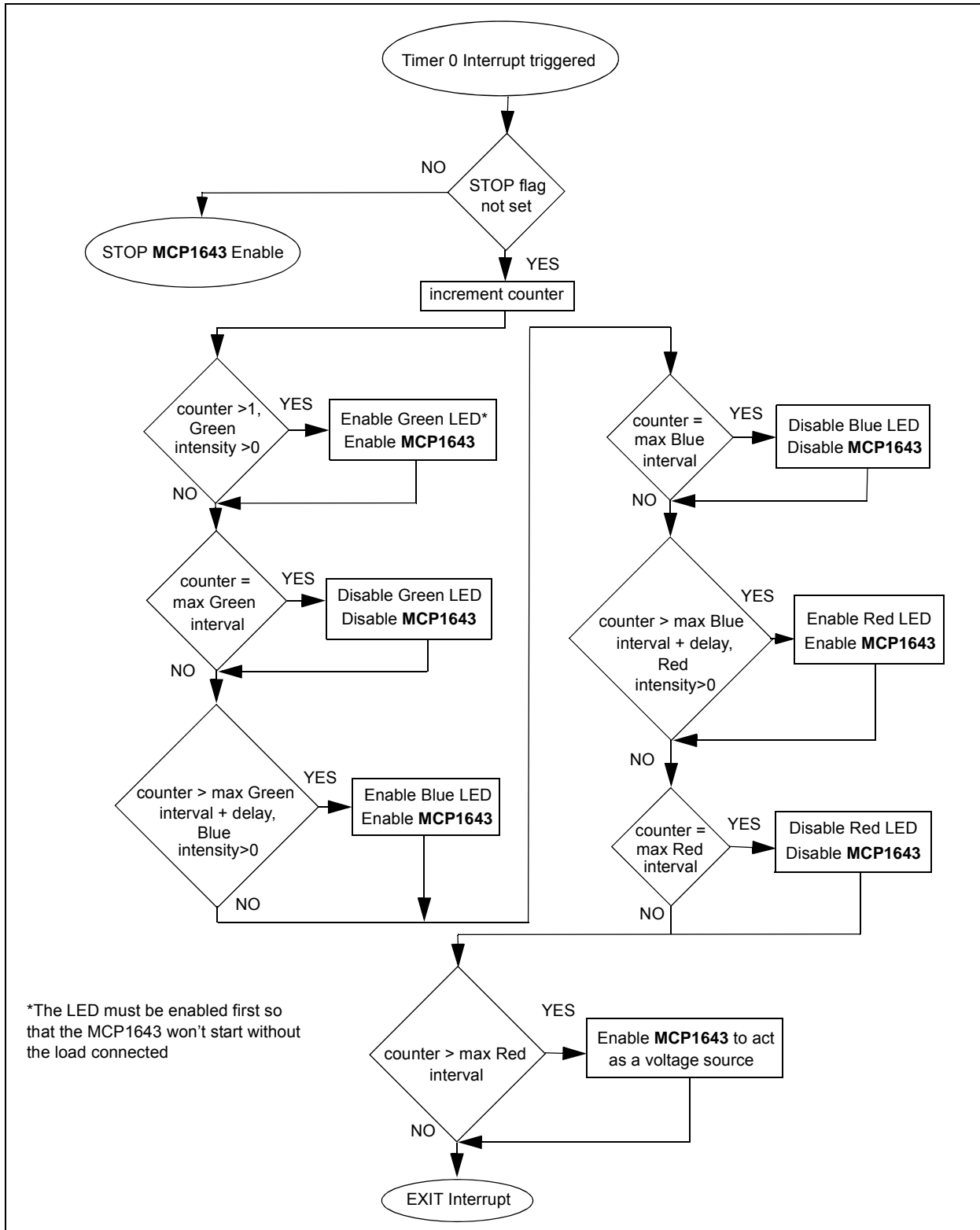
FIGURE 3-2: *Interrupt Code Sequence.*

Appendix A. Schematics and Layouts

A.1   INTRODUCTION

This appendix contains the following schematics and layouts for the MCP1643 RGB LED Driver Demonstration Board:

- Board – Schematic
- Board – Top Silk
- Board – Top Silk and Copper
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Silk and Copper
- Board – Bottom Silk

A.2   BOARD – SCHEMATIC

MCP1643 RGB LED Driver Demonstration Board User's Guide
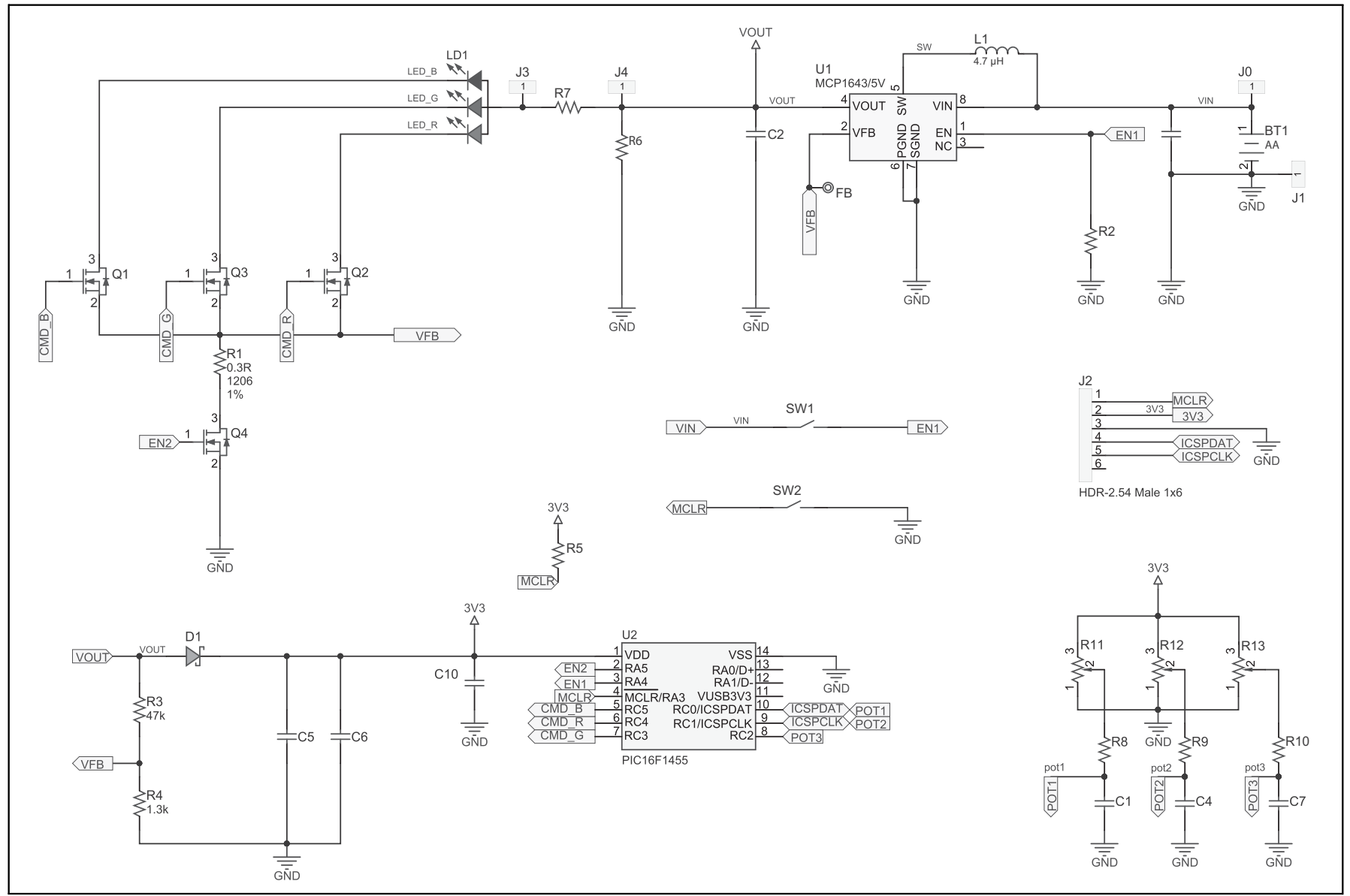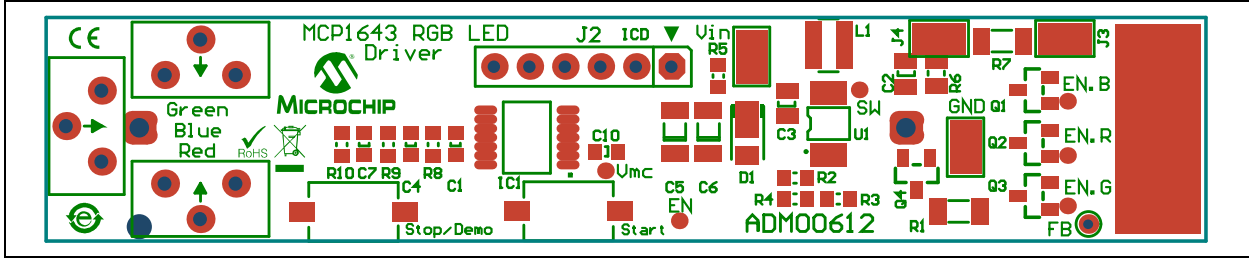
A.3   BOARD – TOP SILK

A.4   BOARD – TOP SILK AND COPPER

A.5   BOARD – TOP COPPER

A.6   BOARD – BOTTOM COPPER

A.7   BOARD – BOTTOM SILK AND COPPER

A.8   BOARD – BOTTOM SILK
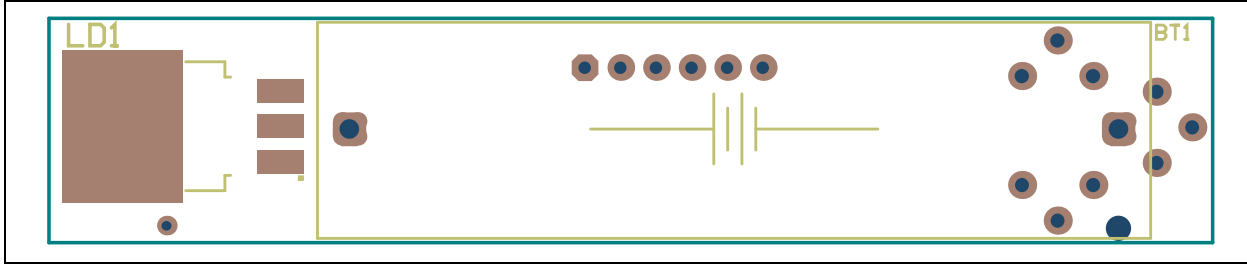
Appendix B. Bill of Materials (BOM)

TABLE B-1:   BILL OF MATERIALS (BOM)

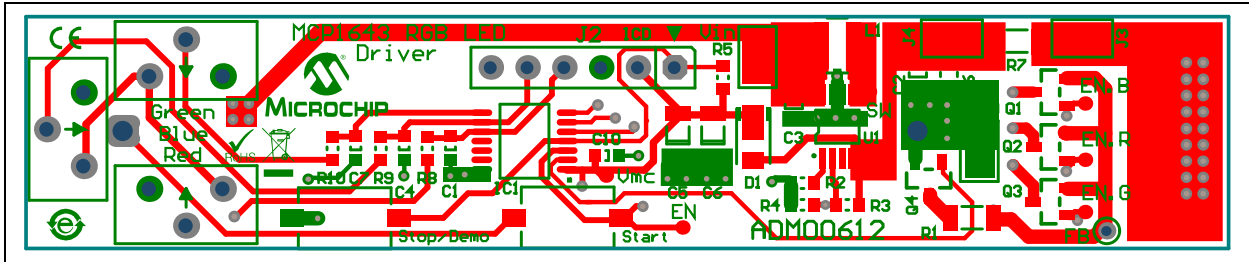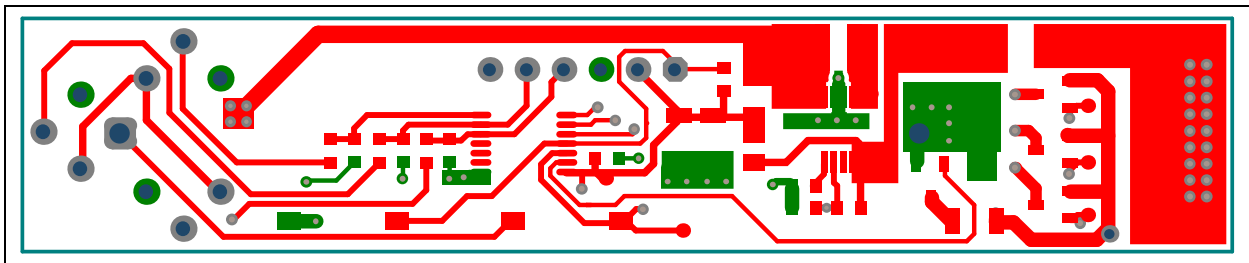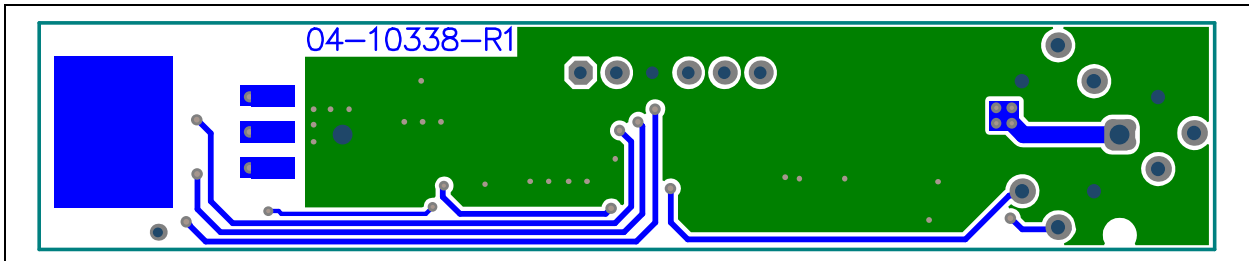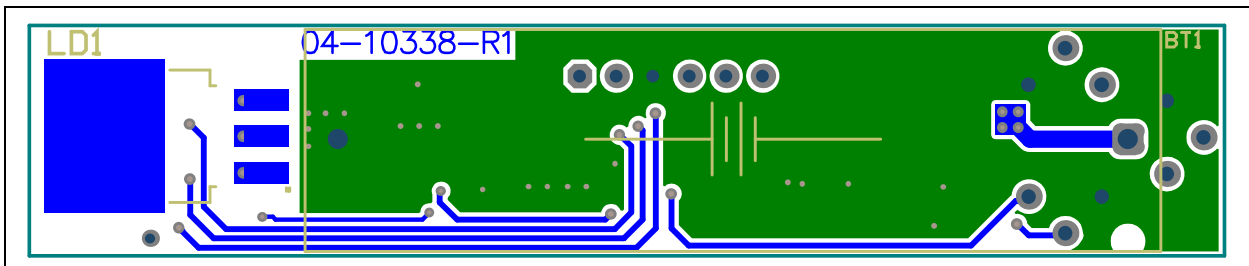| Qty.	Designator	Description	Manufacturer	Part Number
1	BT1	Battery holder 1 TH AA	Keystone Electronics Corp.	1028
0	C1	Capacitor ceramic. 10000 pF 50V 20% X7R SMD 0603 - **DO NOT POPULATE**	TDK Corporation	C1608X7R1H103M
2	C2, C3	Capacitor ceramic 10 µF 16V 20% Y5V SMD 0805	TDK Corporation	C2012Y5V1C106Z
0	C4, C7	Capacitor ceramic 10000 pF 50V 20% X7R SMD 0603 - **DO NOT POPULATE**	AVX Corporation	06035C103KAT2A
2	C5, C6	Capacitor ceramic 100 µF 10V 20% X5R SMD 1206	TDK Corporation	C3216X5R1A107M160AC
1	C10	Capacitor ceramic 1 µF 16V 10% X5R SMD 0603	AVX Corporation	0603YD105KAT2A
1	D1	Diode Schottky PD3S140 490 mV 1A 40V POWERDI-123	Diodes® Incorporated	PD3S140-7
4	J0, J1, J3, J4	Conn. TP loop tin SMD	Harwin Plc.	S1751-46R
1	J2	Conn. header-2.54 male 1x6 tin 5.84 MH TH vertical - **DO NOT POPULATE**	Sullins Connector Solutions	PEC06SAAN
1	L1	Inductor choke 4.7 uH 1.35A 20% SMD L2.8W2.8H2.8	Wurth Elektronik	744025004
1	LD1	Diode LED tri. red, green, blue 2.1V, 3.5V, 3.5V 300 mA, 350 mA, 350 mA SMD TO-252-3	Lumex® Inc.	SML-LX1610RGBW/A
1	PCB1	MCP1643 - Printed Circuit Board	—	**04-10346-1**
4	Q1, Q2, Q3, Q4	Transistor FET N-Channel IRLML2402 20V 1.2A 540 mW SOT-23-3	Infineon Technologies AG	IRLML2402TRPBF
1	R1	Resistor TKF 0.3R 1% 1/4W SMD 1206	Bourns®, Inc.	CRL1206-JW-R300ELF
2	R2, R5	Resistor TKF 10 kΩ 0.1% 1/10W SMD 0603	Panasonic®- ECG	ERA-3AEB103V
1	R3	Resistor TKF 47 kΩ 5% 1/10W SMD 0603	Panasonic - ECG	ERA-3AEB103V
1	R4	Resistor TKF 1.3 kΩ 5% 1/10W SMD 0603	Panasonic - ECG	ERJ-3GEYJ132V
1	R6	Resistor TKF 1 kΩ 1% 1/16W SMD 0805	Stackpole Electronics Inc.	RMCF 1/10 1K 1% R
1	R7	Resistor TKF 0R 1% 1/4W SMD 1206	TT Electronics Plc.	WCR1206-R005JI
3	R8, R9, R10	Resistor TKF 0R 1/10W SMD 0603	NIC Components Corp.	3386X-1-103TLF
3	R11, R12, R13	Resistor trimmer Cermet 10K 10% 500 mW TH 3386X	Bourns Inc.	3386X-1-103TLF
2	SW1, SW2	Switch tactile spst. 12V 50 mA RS285G05A2URT SMD	C&K Components	RS285G05A2URT
1	U1	Microchip Analog switcher boost 5V MCP1643T-I/MS MSOP-8	Microchip Technology, Inc.	**MCP1643T-I/MS**
1	U2	IC MCU 8 bit 14 KB flash 14-lead TSSOP	Microchip Technology, Inc.	**PIC16F1455-E/ST**

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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